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Implications of Biological Trends for Estimation of Biological Reference Points and Rebuilding Schedules: Some Cautionary Notes

by

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> "For relevant stocks, identify trends in biological parameters (i.e., life history and /or recruitment and assess their importance for the computation of BRPs and for specification of rebuilding scenarios"

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Introduction

This paper is a simplified exposition of the potential effects of changes on life history parameters on the estimation of biological reference points and rebuilding strategies. In very basic terms, smaller size at age, delayed maturity at age, and decreased survival of recruits are measures of reduced productivity that induce smaller biomass reference points, lower fishing mortality rates, slower rebuilding rates, lower total landings during rebuilding, and increases in discarding..

All of these consequences can be deduced as simple thought experiments. Such consequences are important for fisheries management and support of fisheries. A more perverse consequence occurs when the trends in biological productivity are unrecognized or masked by other factors. In such instances assessment models will overestimate allowable landings, overestimate spawning stock potential, and lead to overly optimistic predictions of stock recovery. Failing to correct allowable catches for such changes can further reduce stock sizes and curtail nascent recoveries.

Average Weights or Lengths

The effects of reduced average weight at age imply:

- More fish are killed per ton of fish landed or discarded. Therefore quotas need to be reduced to attain the desired mortality rates
- Discarding can increase if technical measures fail to adequately protect undersized fish. Slow-growing strong year classes will be exposed to discard mortality for longer periods of time and more lifetime yield from a cohort will become discards rather than landings.
- Minimum size regulations can become counter productive if large fractions of a slow growing cohort are discarded.
- Even in the absence of discarding, yields from slow growing cohorts would be reduced by natural mortality up to the age when they are legal sized.
- Effectiveness of gear changes, trip limits, and seasonal closures may also be reduced.
- Reduced average size at age may alter the age-specific force of mortality on the population. When such changes are rapid, statistical catch at age models will have to allow for more rapid changes in parameterization of selectivity functions. Similarly, estimation of F on the oldest true age in VPA models can become difficult since its estimation is a structural assumption rather than an estimated parameter.
- To the extent that age or size-specific selectivity is changing over time, the comparability of measures of fishing mortality is compromised. Strictly speaking, measures of F_{full} or F_{mult} are comparable only when the partial recruitment patterns (or selectivity) are constant over time.
- All other things being equal, reduced average weights at age imply lower biological reference points for biomass.

Maturity
Reductions in average weight at age can also be associated with delayed maturation at age. The reproductive potential of a cohort can be reduced by the joint effects of smaller size at age, a reduced mature fraction, and potentially, a lower survival rate of offspring spawned by smaller females. Some evidence suggests that offspring of first time spawners have lower survival rates than those from fish which have spawned in a previous year(s) (e.g. Trippel 1998, Murawski et al. 2001).

Recruitment
Changes in recruitment trends are generally attributed to spawning stock abundance (Brodziak et al. 2001). However, when no parametric function is found acceptable, nonparametric methods are often employed to model the expected value and variance of recruitment. If the sampling moments of the observed recruitment series are used to forecast population size, it is important to establish that the series is stationary. Otherwise, unrecognized declines in average number of recruits will lead to overly optimistic recovery projections toward biomass targets that may be unattainable at prevailing average recruitment rates.

Natural Mortality
Life-history theory often posits associations between growth rate parameters (e.g., von Bertalanfffy) and natural mortality rates. Associations at evolutionary time scales are irrelevant to the inter-annual changes but slow growth rates could be associated with decreased survival when prey are less abundant or during stressful environmental conditions. Undetected changes in natural mortality, if severe, have obvious consequences for estimated stock sizes.

A Couple of Examples
The joint effects of lower productivity would be an academic curiosity if the consequences of undetected changes were not so severe for stock assessments. The consequences for Pacific halibut (Clark et al. 1999) included underestimation of incoming yearclasses that required major changes in the model formulation. More importantly, proper treatment of temporal trends in growth and fishery selectivity “erased the previous appearance of strong density dependence in the stock recruitment relationship, and prompted a reduction in the target full-recruitment harvest rate from 30-35 to 20-25%” (Clark et al. 1999).

Changes in haddock growth rates (TRAC 2007) had important implications for in-season management measures on Georges Bank in 2007. High rates of discards were observed early in 2007 by at-sea observers. The high rates were occurring because the 2003 yearclass, perhaps the largest on record, was growing more slowly than expected and a large fraction of this yearclass was below the minimum size limit. The Multispecies Groundfish Committee proposed a reduction in the minimum size limit from 19 inches (48.3 cm TL) to 17 inches (43.2 cm TL) for haddock caught on the US portion of Georges Bank. The New England Fishery Management Council approved the change. The proposed change in minimum size is expected to increase the fraction of the haddock available for landing in 2007 and 2008 by a factor of 3 (ie. from 22% to 65%). Lowering the size limit would translate discards to landings, if, and only if, no changes in fishing practices or targeting of haddock occur. An increase in fishing effort could negate the conservation neutral effects of a lower size limit.

Summary

All of the processes described above are well known and undoubtedly have some influence on the assessments of the 19 groundfish stocks. The critical issue will be estimating the magnitude of the joint effects of such changes. In terms of biological reference points the key decisions include:

- Selection of the appropriate average weights at age for computation of biomass reference points
- Selection of average weight for the plus group in the projection.
- Selection of maturity schedule
- Partial recruitment (age specific selectivity)
- Number of years to include in stock recruitment function (whether parametric or nonparametric) and how or if to include estimates of recruitment strength from years prior to the assessment.

References

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